Measuring Blood Flow in the Placenta using EPI at 1.5T

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Introduction: Blood flow in placenta is important for fetal growth and development. Intrauterine growth restriction, maternal diabetes and preeclampsia are associated with retardation of blood flow in placenta. Conventionally, the velocity of blood flow within the uterine and umbilical arteries is measured using Doppler ultrasound but this still remains an indirect measure of placental function. More recently MRI has been used to measure placental function using IVIM or ASL. However these techniques measure blood movement rather than bulk flow. However the patterns of blood flow in the placenta are also of interest in understanding the effects of increased uterine artery resistance on percolation of blood through the placenta. This abstract describes the development of velocity encoded MRI to determine the direction and velocity of blood flow through the placenta.

Methods: In this technique development study, with ethics committee approval, 3 healthy pregnant women from Queen's Medical Centre Nottingham were recruited and gave informed consent to participate in the study. The pregnant women underwent scanning session at 34-36 weeks GA. They were scanned using 1.5 T Philips Achieva MRI scanner using, depending on the woman's size, either 5-element SENSE cardiac coil or 4-element SENSE torso coil positioned over the placenta. Women lay on their right side in the decubitus position to avoid vena cava compression; all scans were conducted with a specific absorption rate of <2.0 W/kg. The sequence used to study placental blood flow is flow encoded, 2-shot echo planar imaging (EPI) acquired perpendicular to the uterine wall. Flow sensitization was applied in 3 directions along the imaging axes. Five slices were acquired over the placenta in 1.09 seconds (TR = 3000ms, TE = 134ms, 350x350x107 mm^3 and 5 dynamics venc = 0, 0.1, 0.9 12 and 20 cms^{-1}). The acquisition was respiratory gated and the pregnant women were allowed to breath freely during the scan.

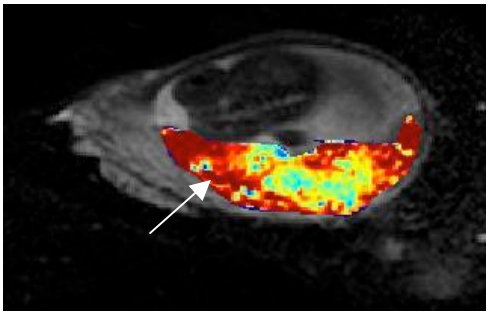

Figure 1: Velocity encoded flow map of the placenta for venc = 20 cms^{-1}. Encoding direction is vertical on this image. Note high and low flow regions in the basal plate (arrow).

Results: The 2-shot images were generally free from artefacts despite the high probability of fetal and maternal motion over the extended acquisition period, however higher flow encoding levels led to severe motion artefacts. For venc = 20 and 0.9 cms^{-1} adequate data was obtained, although with some flow aliasing for venc = 0.9 cms^{-1}. Figure 1 shows that there were areas of particularly high flow (positive and negative) at the basal plate (the region where the placenta embeds into the uterine wall) (figure 1). For these values the resulting values of Maximum, Minimum and Mean flow in a region of interest drawn over the basal plate is shown in table 1.

Discussion: This work has shown that it is possible to measure coherent flow within the placenta despite the problems of maternal and fetal motion, and has made an initial optimization of the velocity encoding gradients to be used. Future work will further optimize the gradient moments, and will develop histogram analysis methods to determine the range of flows within the placenta. Patterns of flow will also be analysed. Finally this technique will be used in a study of diabetic pregnancies.

Venc (m/s)	0	2	2	2	5	5	5
Direction	.	M	P	S	M	P	S
Maximum flow (m/s)	1.72	2.2	3.17	1.27	3.99	2.38	3.82
Minimum flow (m/s)	-1.37	-1.32	-1.47	-2.46	-3.93	-2.72	-3.47
Mean flow (m/s)	0.11	0.04	-0.28	-0.16	0.33	-0.46	-0.27

Table 1: Showing range and mean flow levels measured for different directions of flow encoding for the two usable flow encoding levels (venc).

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